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The pineal eye of the vertebrate may be reduced back to the three-layered Arthropod type. There is another more rudimentary pineal eye which belongs to the left side, while the previous one connects with the right ganglion habenulæ. The brain of Ammocœtes almost compels us to recognize the supraœsphageal ganglion of the Crustacean, etc.

If any one hopes to find a grain of truth in either of these two contradictory theories, which exhibit wonderful displays of mental gymnastics, starting from the Arthropods as from a spring-board, thence to take their aërial flight, let such a person read them side by side.

ENTOMOLOGY.[1]

A Review of Some Plum Curculio Literature.—A few years hence, when it is finally and definitely settled whether the Plum Curculio (*Conotrachelus nenuphar*) can be successfully fought on a commercial scale by spraying with the arsenites, there will be an opportunity to write a most curious and instructive chapter in the annals of economic entomology. This question has been under discussion by entomologists for more than twenty years, and to judge from the latest publications concerning it, the end is yet in the distant future. Nearly all our economic entomologists have taken part in the discussion, and the final record will show a curious mixture of assent and dissent on the part of those concerned.

Before attempting a brief analysis of this record, I desire to quote from a letter recently published in *Agricultural Science* (Vol. IV., p. 97), in which I made the following statements concerning the philosophy of spraying with the arsenites, and the conditions necessary for a fair test: "The remedy undoubtedly acts mainly by destroying the adult beetles that feed upon the poisoned surface of the fruit and foliage, thus preventing, to a greater or less extent, the deposition of the eggs. It need not necessarily act at all upon the beetles when engaged in oviposition, nor upon the larvæ after hatching. Consequently a fair test cannot be carried on with a half dozen trees close together, three of which are sprayed and the others not. Beetles from the unsprayed trees may oviposit in the fruit of those sprayed, and the beetles killed on the sprayed trees will lessen the injury to their checks. For the same reason a fair test cannot be carried on in an orchard in which every alternate tree is sprayed. A conclusive experiment necessitates an orchard of considerable size,—one half to be sprayed and the other half either to be jarred or left untreated,—or else two orchards near together, with a similar difference in treatment. Of course, by the every-other-tree method, results of some value may be obtained, but the conditions of the commercial orchard, where all the trees are sprayed, are far from being reached."

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[1] Edited by Dr. C. M. Weed, Experiment Station, Columbus, Ohio.

So far as entomologists are concerned, the discussion of this subject appears to have begun in 1870, when Dr. C. V. Riley wrote the following paragraph upon it: [2]

"Mr. G. M. Smith, of Berlin, Wisconsin, . . . recommends Paris green for the Plum Curculio. Even if the uniform application of such a poisonous drug on large trees were practicable, it would never succeed in killing one Curculio in a hundred. Paris green kills the leaf-eating beetles by being taken internally with the leaves; but the Curculio, with its snout, prefers to gouge under the skin of the fruit, and only exceptionally devours the leaves. Yet, notwithstanding the palpable absurdity of the remedy, it has very generally passed from one journal to another without comment."

Fifteen years later Dr. Riley delivered an address before the Mississippi Valley Horticultural Society, in which, "in giving his experience as to the feeding habits of the beetles, he urged experimentation with the arsenites in this direction as promising fair results, though in the very nature of the case not as satisfactory as in the case of the Codling Moth." [3]

In November, 1888, Dr. Riley, in reviewing a bulletin by Professor A. J. Cook, in which the latter reports successful results with the arsenites as Curculio destroyers, wrote: [4]

"We have long felt that they [the arsenites] might be used with benefit for this purpose, but from the nature of the case we have anticipated less good than in the case of the apple worm, and Professor Forbes's experiments, and some unpublished experiments which we have had made by Mr. Alwood, confirm this view."

Shortly after this Dr. Riley read an elaborate paper concerning the Plum Curculio before the American Pomological Society, at its meeting in February, 1889, in which the use of arsenical sprays was especially discussed. This article, in substantially the same form, was also incorporated in the memoir upon the Plum Curculio published by Riley

[2] Third Report State Entomologist Missouri, p. 18.

[3] Riley. Rept. Am. Pom. Soc., 1889, p. 31.

[4] *Insect Life*, November, 1888, Vol. I., p. 123.

and Howard in the Report of the U. S. Department of Agriculture for 1888. In this article the author summarized the experiments of Alwood, Cook, Osborn, Forbes, and Weed, and made the following concluding statement:[5]

"On the whole, the remedy is one which is a desirable addition to our list, although it will never become so great a success as the application of these poisons for the Codling Moth, and for two reasons: (1) The egg is deposited, and the beetle gnaws, preferably upon the smooth cheek of the fruit, where the poison does not so readily adhere, and from which it is more easily washed off; (2) the larva, eating directly from the flap, does not come in contact with the poison, as does the larva of the Codling Moth."

In the Department Report article already referred to Riley and Howard state that "there can be no doubt but [that] practical use has demonstrated that the jarring method is the most effective way yet proposed for destroying these insects."[6]

I have already called attention[7] to the fallacy of the arguments contained in the next to the last of these paragraphs; but as the periodical in which my letter was published seems not to be generally circulated among entomologists, and as there was also a printer's blunder which misrepresented my remarks, they may be quoted in this connection. Referring to the reasons given for the assertion that spraying for the Curculio "will never become as great a success" as in the case of the Codling Moth, I said: "The fallacy of these arguments lies in the assumption that the *modus operandi* of the method is the same for both insects,—an assumption that obviously is not justified by facts. In the case of the Codling Moth, the remedy acts by destroying *the larva after it has hatched from the egg*, while with the Curculio it acts by destroying *the beetle before the eggs are laid.* This throws the arguments concerning the place of oviposition and the food habits of the larva entirely out of court, leaving only that expressed in the phrase, 'The beetle gnaws preferably upon the smooth skin of the fruit, where the poison does not so readily adhere [as in the calyx of the apple?], and from which it is more easily washed off.' To what extent this is true, and what importance should be attached to it under the circumstances, are openquestions. The green fruit of many, at least of the so-called foreign plums, is covered with a fine pubescence, in which particles of London purple or Paris green readily lodge, and are not easily blown or washed away.

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[5] Rept. Am. Pom. Soc., 1889, p. 34.

[6] Report U. S. Department Agriculture, 1888, p. 68.

[7] *Agricultural Science*, Vol. IV., p. 98.

"Clearly, if the question of comparative efficiency raised in the paragraph quoted above is to rest on a rational basis, it must be put in something like the following form: Is the deposition of Curculio eggs prevented (through the destruction of the parent beetles) by the application of arsenites to plum trees in as great a proportion as Codling Moth larvæ are destroyed by the same applications to apple trees? It is probable that each female Codling Moth and Plum Curculio deposits on an average about fifty eggs, so that, reduced to figures, this question resolves itself into the following: Is the application of the arsenites as likely to kill one adult female Curculio, feeding indiscriminately over a large amount of poisoned surface, before it has deposited eggs, as it is to kill fifty Codling Moth larvæ before they enter the apples.

"In order to get at field conditions, suppose that in an orchard of 1,000 apple trees there was a female Codling Moth to each tree, and that in an orchard of 1,000 plum trees there was a female Curculio to each tree. It is usually estimated that seventy-five per cent. of the fruit liable to injury by the Codling Moth is saved by spraying; so it becomes a question of whether spraying will be as likely to destroy the equivalent of 750 female Curculios before their eggs are laid, as it will to destroy 3,750 Codling Moth larvæ after they hatch. The answer to this question will be found along the experimental rather than the *a priori* road."

It will readily be granted, from the explanation already given, that if the case be restricted to a single tree, or a few trees in the midst of other trees liable to injury by the Curculio, the odds would be in favor the Codling Moth, at least for the first brood, but on a commercial scale the above reasoning must apply.

The writings of Professor A. J. Cook form an important part of the discussion upon this subject. During the first six or seven years of the last decade he frequently expressed the opinion that the Curculio could not be destroyed by the arsenites. For instance, in 1886 he is on record as saying:

"Paris green, kerosene emulsion, and other poisons are of no avail against the Curculio. He will not eat them."[8]

In 1887 Professor Cook took up the subject in an experimental way. The only record of the season's work is the following paragraph:[9]

"Paris green, in the proportion of one tablespoonful to six gallons of water, was very thoroughly sprayed upon four plum trees, May 18th. The petals had all fallen, but the dried calyces still clung to the fruit. On August 20th the trees were visited, when it was found that the two treated trees of the Wild Goose variety had dropped all their fruit, as had the untreated trees of the same kind. Another treated tree of a yellow variety was loaded with plums, of which only fifteen per cent. were stung, and those not badly. The fourth tree treated was a purple variety, and had not less than seventy-five per cent. of its fruit badly stung."

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[8] Report Mich. Board of Agriculture, 1886, p. 141.

[9] Report Mich. State Board of Agriculture, 1887, p. 40.

Professor Cook wisely refrains from drawing any conclusions from an experiment of such doubtful value. It is extremely probable that the Curculio had nothing to do with the dropping of the fruit on the Wild Goose trees, as this variety nearly always drops its fruit just after it sets, on account of the lack of fertilization of the ovule. The two remaining trees about offset each other, one having seventy-five per cent. of wormy fruit, and the other eighty-five per cent. of sound plums. The trees were sprayed but once, and a period of more than three months apparently elapsed during which no observations were made upon them.

In 1888 Professor Cook repeated the experiment, apparently on a slightly larger scale. An unrecorded number of cherry trees and three plum trees were sprayed with London purple, one pound to 100 gallons of water, June 6th, 12th, and 20th. The sprayed fruit of both kinds matured with little or no Curculio injury, while "cherry and apple trees near by not sprayed suffered seriously." The author gives the following conclusions :[10]

"From these experiments, and those of former years, I conclude that while one application will not save our plums and cherries, and prevent apples from being stung, two or three applications may be of signal advantage."

The experiments were repeated in 1889 "with no success. All the trees were severely attacked and all the plums lost." Nothing is said concerning cherries. Professor Cook thinks he is "warranted in the following conclusions :"[11]

"The arsenites will protect against the Plum Curculio if they can be kept on the tree or fruit. But in case of frequent rains the jarring method will not only be cheaper but much more effective."

Finally, in 1890 Professor Cook issued as Bulletin No. 66 of the Michigan Agricultural College, an article entitled "Fighting the Plum Curculio," in which spraying is entirely repudiated, and "the old reliable method" of jarring is fallen back upon as "the surest, cheapest, and best method to banish the Curculio and save our plums." As before, no details of experiments justifying such an entomological

[10] Bull. No. 39, Mich. Agr. College, p. 9.

[11] Proc. Tenth Meeting Soc. Prom. Agr. Science, 1889, p. 28.

stepping backward are vouchsafed, the entire record being embraced in the following paragraph:

"Trees were very thoroughly sprayed, at intervals of ten days, as many as five times, and after each rain, and yet in several cases every plum was stung and fell off. Some small trees, heavily loaded, were sprayed, and though no rain came to remove the poison, yet in less than a week all the plums were stung by the Curculio. Both last year and this, with the exception of one tree, nearly all the plums were stung. These fell from the tree, were all gatherd up and cut open, that we might be sure that the grubs were present."

This record is remarkable for the absence of any indication of details from which one might get an idea of the fairness of the experiment. We do not know the number, size, position or variety of the trees sprayed; nor whether they were surrounded by unsprayed trees; nor the dates of spraying; nor the amount of rainfall; nor the poison used; nor the proportion of poison and water; nor the method of spraying; nor whether the work was done under the author's personal supervision, or by untrained and inexperienced assistants. The present writer has learned from conversation with Professor Cook that ten trees only were included in the test.

These Michigan experiments for several years past, which are being quoted far and wide, are all open to the following objections:

(1) They have not been carried on with a proper understanding of the theory upon which the remedy rests. As a consequence, the every-other-tree method, or the method of a few trees treated among many untreated, has been employed,—methods by which no results of value to the commercial grower can be obtained.

(2) They have been conducted, so far at least as the record indicates, on too small a scale.

(3) The records of the experiments are incomplete and unsatisfactory. Nearly all of the details essential to a full knowledge of the force of the experiments are omitted.

Professor Herbert Osborn, in 1888, made some experiments on the grounds of the Iowa Agricultural College, which have been quoted by Riley and Howard in the Plum Curculio article already referred to. A few trees of native varieties were sprayed twice, among others not sprayed. Only a small proportion of the plums were injured in either case, and the experiment showed a small percentage in favor of the sprayed trees. But there were two insects engaged in the work,—the Curculio and the Plum Gouger (*Coccotorus prunicida*),—and the injuries of each were not separated. Careful observations made in the same region, and presumably in the same orchard, the next year, by Mr. C. P. Gillette, showed that ten times as much injury was done by the Gouger as by the Curculio. Consequently, so far as the Curculio is concerned, this experiment might well have been left out of the record.

In 1889 Mr. C. P. Gillette made some careful experiments on native varieties of plums at the Iowa Experiment Station, apparently on the same orchard that Professor Osborn had worked in the year before. Mr. Gillette recognized the dangers of the every-other-tree method, making a distinct statement of the principles involved, in the Bulletin of the Iowa Experiment Station for May, 1890 (pp. 383–384), shortly after the publication of my letter in *Agricultural Science*, which, however, he had probably not seen when his article was written. The percentage of Curculio injury on both sprayed and unsprayed trees was extremely small, though "the indicated saving of fruit that would have been injured in the absence of treatment was forty-four per cent." In this experiment only two sprayings were made, and, as the author states, both were too early to take most effect upon the Curculio.

The conclusions concerning the Curculio reached by Professor Forbes, in his admirable experiments in spraying apples for the Codling Moth, have frequently been quoted to show that the benefit to be derived from spraying for the insect is much less than in the case of the Codling Moth. But, aside from the fact that in these experiments the injuries of the Apple Curculio (*Anthonomus quadrigibbus*) and the Plum Curculio are not separated,—which alone would vitiate the conclusions so far as they relate to the latter insect,—a few trees were sprayed in the midst of others untreated, so that, from the principle already stated, results of little value, so far as the Plum Curculio is concerned, could be expected.

In 1887 Mr. W. B. Alwood made some experiments on the grounds of the Ohio Experiment Station, on the strength of which he has frequently claimed priority in demonstrating the usefulness of the arsenites as Curculio destroyers. No record of them was published until 1889, when they were incorporated in Dr. Riley's American Pomological Society article, and also in the Riley-Howard memoir in the Department of Agriculture Report for 1888 (pp. 70–71). Three plum trees of the Green Gage variety were treated in the midst of about twenty-five untreated trees of four other varieties. One Green Gage was left as a check. Paris green, at the rate of one pound to fifty gallons of water, was applied May 13th and 17th. Of course two such strong applications, only four days apart, greatly injured the foliage, so that "fully fifty per cent. fell off." Mr. Alwood continues:

"The trees were set very full of fruit, and much of this withered and fell. However, fully one-half of a crop was matured. There was one other tree in the orchard of this variety, and it matured more fruit than the other varieties, but not one-half as much as those which had been so thoroughly treated with the poison. This tree was set in spring as full as they were. It seems possible from this note that the gages are not so much injured by the Curculio as the other varieties. However, this is not at all certain."

It is needless to state that this part of Mr. Alwood's experiment proved nothing. He also sprayed some cherry trees, treating one row with Paris green once, and another with kerosene emulsion once. This experiment was even more fruitless than that on the plum, and was abandoned before final results were obtained. Some experiments of decided value, however, were made by Mr. Alwood upon feeding poisoned fruit and foliage to Curculios in confinement, which will be referred to later.

My own experiments upon this subject began in 1888, when seventy-five Early Richmond cherry trees, occupying a half-acre block, were chosen for this work. The west half of the orchard was sprayed, and the east half left as a check. London purple was applied three times, in the proportion of eight ounces to fifty gallons of water. At time of ripening, eight sprayed trees and seven check trees were selected, and 1,000 cherries from each were critically examined for Curculio injuries. It was found that 14.5 per cent. of the unsprayed fruit gave evidence of Curculio attack, while 3.5 per cent. of the sprayed fruit was injured. There was consequently a percentage of benefit of 75.8. The same year similar experiments were made upon plums and pears, but as stated in the record[12] the opportunities for a satisfactory test were not so good as with the cherries, so that, although the fruit was saved, less stress was laid upon the results.

In 1889 the cherry experiment was duplicated, the parts of the orchard being reversed to eliminate any possible effect upon the results that might be due to the situation. In 1888 the west half was sprayed, and the east half left as a check; in 1889 the east half was sprayed, and the west left as a check. London purple was applied three times, in the proportion of one pound to 160 gallons of water. At time of ripening, 1,000 cherries were picked from each of twenty-four trees in each half of the orchard—a total of 48,000 cherries—and examined for Curculio injuries. The percentage of injury on the untreated trees was 6.17, while on the treated trees it was 1.5. This gives a percentage of benefit of 75.6,—just .2 per cent less than in 1888. Plums sprayed with a combination of London purple and the Bordeaux mixture matured a full crop, while unsprayed trees a few rods distant lost all their fruit. The record of this year's work will be found in the Bulletin of the Ohio Agricultural Experiment Station for September, 1889 (Vol. II., pp. 133–143).

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[12] Seventh Annual Rept. Ohio Agr. Exp. Station, pp. 134–150.

While these experiments were made as complete and satisfactory as the circumstances would permit, and every essential detail was inserted in the records, they were open to three objections, namely: First, that while the remedy might work in a region like Central Ohio, where fruit-growing forms only a small proportion of the agricultural interests of the inhabitants, and where the Curculio, though abundant, is not so overwhelmingly present as in a region almost exclusively devoted to fruit production, it might be impracticable in the latter region; second, that the plum orchard was not sufficiently large to make a test under the conditions of the commercial orchardist; and third, that the cherries upon which some of these experiments were conducted ripened before the season of egg deposition of the Curculio was over. The force of these objections was fully appreciated while the experiments were in progress, but the work was done in the belief that results of value could be so obtained, and with the expectation of giving the method a thorough trial, from the standpoint of the commercial orchardist, if the preliminary tests were sufficiently encouraging.

The present season a plum orchard of 900 bearing trees in Ottawa county, Ohio, right in the heart of a great fruit-growing region, was selected for the experiment. In the north half of it the method of catching the Curculios by jarring on a sort of inverted umbrella mounted on wheels was employed, while the south half was sprayed four times with pure Paris green mixed with water, in the proportion of four ounces to fifty gallons.

The first application was made May 8th, just after the blossoms had fallen from the late-blooming varieties. There was a heavy rain the same night, and it rained almost continuously until May 15th, when there was a short cessation. The second spraying was done on that day. The third spraying was made May 26th, and the fourth and last, June 2d.

On the jarred portion of the orchard a great many Curculios were caught, showing that they were present in numbers. A careful examination of both parts of the orchard was made on June 3d. Between one and two per cent. of the fruit on the sprayed trees had been stung, while about three per cent. of the plums on the jarred trees were injured. No damage to the trees was then perceptible.

Early in July the orchard was again examined. Some of the sprayed trees showed that the foliage had been damaged by the spraying, but the injury was not very serious. Not over three per cent. of sprayed fruit was stung at that time, while about four per cent. of that on the jarred trees were injured. But on both the fruit was so thick that artificial thinning was necessary to prevent overbearing.

A large crop of fruit was ripened on both parts of the orchard, and so far as could be judged from one field experiment, it showed that spraying is as effective as jarring.[13]

Professor Cook, referring to this experiment, has asked: "Would the crop have been a failure had he not sprayed? And, if so, will he get equal results every season?"[14] To the first question I can only answer that in the jarred half of the orchard large numbers of Curculios were obtained,—enough to ruin the crop had they not been caught. It is fair to presume that they were equally abundant in the sprayed half. The second question is easily answered. If the crop would have been a failure without spraying, obviously the spraying saved it. And if the success was due to spraying alone—a condition involved by the query itself—future experience must conform to that of the past. I do not say that this is all demonstrated, but simply answer the question with the premise involved in it. Professor Cook continues: "Occasionally we secure a crop, with no effort to fight the Curculio. Does not this suggest an explanation why some who have given this remedy a limited trial speak so highly of it." If the "*limited* trial" refers to the Ohio experiments, which have been carried on for three successive seasons, and in which an aggregate of 1,200 fruit trees have been employed, I would venture to inquire what constitutes an *extended* trial? There is certainly nothing in the record of the Michigan experiments to indicate that half this number of trees have been employed.

I had intended briefly to summarize the records concerning the feeding habits of the Curculio, and the laboratory experiments in poisoning it, but the limits of space forbids so doing. Suffice it to say, that Dr. Riley in his earliest articles showed conclusively that the adult beetles feed freely upon the fruit and foliage, and that the subsequent observations of Forbes, Comstock, Cook, Gillette, Osborn, Alwood, and others abundantly confirm his account; while the feeding of poisoned fruit and foliage to beetles in confinement by

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[13] This experiment is recorded in Bulletin Ohio Agr. Experiment Station, Vol. III., pp. 225–228; September, 1890.

[14] Bulletin No. 66, Mich. Agr. College, p. 6.

Forbes, Cook, and Alwood have rendered it certain, to use the words of the first-named experimenter, that "there can be no further question of the liability of the Curculio to poisoning by very moderate amounts of either London purple or Paris green while feeding on the leaves and fruit of peach and plum." [15]

It is sincerely to be hoped that future experiments upon this subject will be conducted with a proper understanding of the *rationale* of the method, and on a sufficiently extended scale to give results of value to the commercial orchardist. The experience of another season has strengthened my conviction of the force of the following statement (written nearly a year ago, and published in the *Agricultural Science* letter already referred to), with which this review may well be ended: "It seems to me that the evidence now in hand is sufficient to point to the conclusion that spraying with the arsenites is a complete and practical remedy for the Plum Curculio, at least in good-sized orchards of cherries, plums, and apples; and that the experiment stations can best serve horticulture by encouraging the practice among commercial orchardists, and carefully recording the results obtained, so that they may be collated in the future, and a definite conclusion be reached. If the simple process of spraying is effective, it is useless to complicate matters by advising jarring in wet seasons, planting plum trees in apple orchards, or various other modifications of the treatment that have been suggested."—CLARENCE M. WEED.

ARCHÆOLOGY AND ETHNOLOGY.

The Societe d'Anthropologie at Paris.—*A Sketch of Its Organization and Work.*—The year 1859 was one memorable in the science of anthropology. In this year was published Darwin's work on the "Origin of Species." Whatever may be the truth of the theory announced by him, whatever degree of opposition it may have received, its appearance in the world marked an era in science.

In 1859 was also discovered, or rather was acknowledged as true, the discovery by Monsieur Boucher de Perthes of the paleolithic implements in the gravels of the river Somme. He had made this discovery originally in the year 1836, and had published as a result thereof several brochures, but they were not generally accepted or received in the scientific world until 1859.

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[15] Forbes. *Insect Life*, Vol. II., p. 7; July, 1889.